Phys 131
Fall 2014

Fundamental Mechanics: Class Exam I

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Name: Taylor Larrechea **Total:** /70

Instructions

- There are 7 questions on 5 pages.
- Show your reasoning and calculations and always justify your answers.

Physical constants and useful formulae

$g = 9.80\,\mathrm{m/s^2}$

Question 1

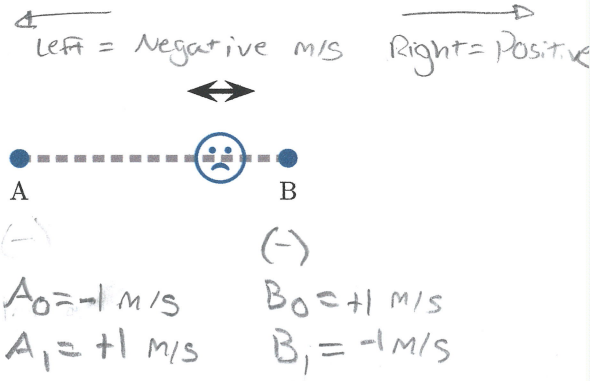
An atom in an atomic trap bounces back and forth along a straight line between the points labeled A and B. As it approaches A it slows, then reverses direction and speeds up toward B. As it approaches B it slows, then reverses direction and speeds up toward A. Which of the following (choose one) is true of the atom's acceleration?

a) Positive at both A and B.

b) Negative at both A and B.

c) Positive at A, negative at B.

d) Negative at A, positive at B.



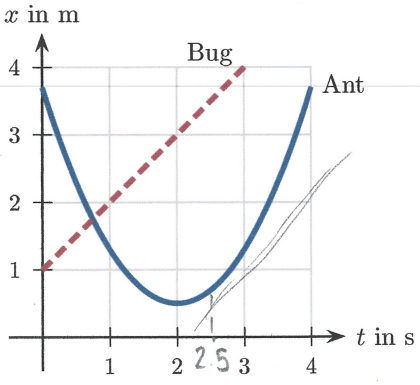
$$A = \frac{\Delta x}{\Delta t} = \frac{1+1}{1-0} = 2\,m/s$$

/5

$$B = \frac{\Delta x}{\Delta t} = \frac{-1-1}{1-0} = \frac{-2}{1} = -2\,m/s$$

Question 2

An ant and a bug walk along a straight sticks. The solid graph illustrates the ant's position vs. time. The dashed graph indicates the bug's position vs. time. Indicate (approximately) the instant at which the bug and the ant have the same velocity.
Explain your answer.



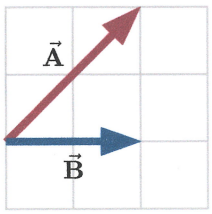
The ants velocity and the bugs velocity are equal at time t=2.5s This is because the slopes of the lines here are equal;

Velocity = $\frac{\Delta y}{\Delta t}$

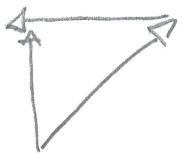
/8

Question 3

Consider the two vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ as illustrated. Which of the following (choose one) illustrates the direction of $\vec{\mathbf{A}} - \vec{\mathbf{B}}$ most accurately?



a) ↑
b) ↓
c) ←
d) ↙
e) ↗



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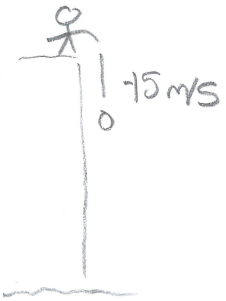
Question 4

A ball is thrown straight down from the top of a building with a speed of 15 m/s. The ball takes 1.25 s to reach the ground. Determine the height of the building.



$V_{1y} = V_{oy} + a_y \Delta t$

$V_{1y} = -15\,m/s - 9.8\,(m/s^2)(1.25\,s)$

$V_{1y} = -15\,m/s - 12.25\,m/s$

$V_{1y} = -27.25\,m/s$

$V_{1y}^2 = V_{oy}^2 + 2a_y \Delta y$

$(-27.25\,m/s)^2 = (-15\,m/s)^2 - 19.6\,m/s^2\,\Delta y$

$742.563\,m^2/s^2 = 225\,m^2/s^2 - 19.6\,m/s^2\,\Delta y$

$517.563\,m/s = -19.6\,m/s^2\,\Delta y$

$\Delta y = -26.4\,m$

$t_0 = 0s$ $\quad X_0 = 0m$ $\quad y_0 = 26.4\,m$ $\quad V_{ox} = 0m/s$ $\quad V_{oy} = -15m/s$ $\quad a(y) = -9.8\,m/s^2$

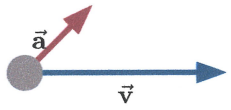
$t_1 = 1.25s$ $\quad X_0 = 0m$ $\quad y_1 = 0m$ $\quad V_{ox} = 0m/s$ $\quad V_{1y} = -27.25\,m/s$ $\quad a(y) = 9.8\,m/s^2$

26.4 m high

/12

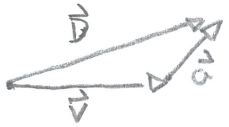
Question 5

An object has the illustrated acceleration and velocity vectors at one instant. Describe whether the object is speeding up, slowing down or moving at constant speed. Describe whether the object moves in a straight line or curves up or down. Explain your answers using vectors.

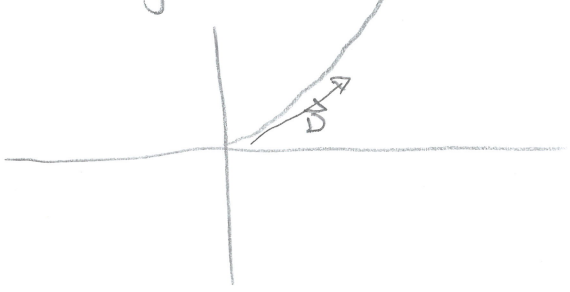


Displacement vector $= \vec{v} + \vec{a}$

$\vec{D} =$



The object is speeding up at a constant acceleration. And since the speed is accelerating at a constant rate, the graph would look something like this



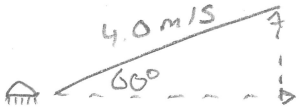
/10

Question 6

A bug sits on the floor and launches itself with a speed of 4.0 m/s at an angle of 60° from the horizontal. It lands on the side of a box at a moment 0.60 s from when it launched.

a) Determine the height (above the floor) of the part the box where the bug lands.

$\Delta t = 0.60\,s$



X-component is

$X = h\cos\theta$

$4\cos 60$

$X = 2\ m/s$

Y-component is

$Y = h\sin\theta$

$4\sin 60$

$Y = 3.5\ m/s$

$V_{iy} = V_{oy} + a_y \Delta t$

$V_{iy} = 3.5\,m/s - 9.8\,m/s^2(0.6s)$

$V_{iy} = -2.38\ m/s$

$V_{iy}^2 = V_{oy}^2 + 2a_y \Delta y$

$(-2.38)^2_{m/s} = (3.5)^2_{m/s} - 19.6_{m/s^2}(\Delta y)$

$5.6644_{m/s} = 12.25_{m/s} - 19.6(\Delta y)$

$-6.59\ m/s = -19.6\ m/s^2 \Delta y$

$0.34 = \Delta y$

$t_0 = 0s$ $\quad x_0 = 0m$ $\quad y_0 = 0m$ $\quad V_{ox} = 2m/s$ $\quad V_{oy} = 3.5m/s$ $\quad a_{(y)} = -9.8m/s^2$

$t_1 = 0.6s$ $\quad X_1 = 1.2m$ $\quad y_1 = 0.34m$ $\quad V_{\phi x} = 2m/s$ $\quad V_{iy} = -2.38m/s$ $\quad a_{iy} = -9.8m/s^2$

0.34 m above floor

b) Determine the horizontal distance traveled by the bug.

$X_1 = x_0 + V_{ox}\Delta t + \frac{1}{2} a_x (\Delta t)^2$

$X_1 = 0m + 2m/s(\Delta t) + 0$

$X_1 = 2m/s(0.6s)$

$X_1 = 1.2\ m$

$t_0 = 0s$ $\quad x_0 = 0m$ $\quad y_0 = 0m$ $\quad V_{ox} = 2m/s$ $\quad V_{oy} = -3.5m/s$ $\quad a_{oy} = -9.8m/s^2$

$t_1 = 0.6s$ $\quad X_1 = 1.2m$ $\quad y_1 = 0.34m$ $\quad V_{ix} = 2m/s$ $\quad V_{iy} = -2.38m/s$ $\quad a_{iy} = -9.8m/s^2$

Horizontal is 1.2 m

Question 6 continued ...

c) Determine whether the bug passes the highest point of its trajectory before it lands on the box (i.e. is returning back to the floor or is still rising when it lands on the box).

Highest point is when $V_{1(y)} = 0$

$V_1(0) = 3.5\,m/s - 9.8\,m/s^2 \Delta t$

$-3.5\,m/s = -9.8\,m/s^2 \Delta t$

$\Delta t = 0.36$ when $V_{1y}(0) = 0$

The bug passes its highest trajectory when $t = 0.36$ s. It is returning to the floor when it hits the box.

$t_0 = 0s$ $t_1 = 0.6s$

$x_0 = 0m$ $x_1 = 1.2m$

$y_0 = 0m$ $y_1 = 0.34m$

$V_{0x} = 2\,m/s$ $V_{1x} = 2\,m/s$

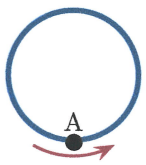
$V_{0y} = 3.5\,m/s$ $V_{1y} = -2.38\,m/s$

$a_{0y} = -9.8\,m/s^2$ $a_{1y} = -9.8\,m/s^2$

/25

Question 7

An ant walks with a constant speed all the way around a circular loop of wire. Which of the following (choose one) regarding the ant's instantaneous acceleration, $\vec{a}$, at point A is true?



a) $\vec{a} = 0$.

b) $\vec{a} \neq 0$ and is $\uparrow$.

c) $\vec{a} \neq 0$ and is $\downarrow$.

d) $\vec{a} \neq 0$ and is $\rightarrow$.

/5